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TITLE: INDUCTION SURFACE HARDENING METHOD AND LOOP-SHAPED HIGH
FREQUENCY INDUCTION COIL USED THEREFOR

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ABSTRACT:

PURPOSE: To harden the outer peripheral surface of a bent work to a uniform hardness, by heating and hardening the outer peripheral surface of the bent work such as a crank shaft having different rotation centers while it is rotating on its own axis with a loop-shaped high frequency induction coil having an internal shape which is nearly equal to that of the bent work.

CONSTITUTION: A bent work 1 of irregular shape such as a crank shaft is attached to the top end of a supporting rod 14 which revolves around the rotating axis 13 and the work 1 is rotated on its own axis. The bent work 1 is heated by a high frequency induction coil 7 and is quenched in a cooling fluid 15. The high frequency induction coil composed of a pair of circumferential coils 8, 8' and a pair of axial coils 9, 9', and both the coils are connected alternately and surround the work 1. The axial coils 9, 9' are nearly equal in shape to the outer peripheral breadth of the outer peripheral locus of the work 1, the locus which becomes most distant from an axis 2 when the work 1 rotates around the center axis 2. The outer peripheral surface of the work 1 which rotates on its own axis is heated uniformly, hence it is hardened to a uniform

hardness all over the work 1.

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⑭高周波表面焼入方法並びにそれに用いるループ状高周波誘導コイル体

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明　細　書

1. 発明の名称

高周波表面焼入方法並びにそれに用いるループ状高周波誘導コイル体

2. 特許請求の範囲

(1) 軸心を異にする異形屈曲物のワーク(1)を自転させながら、このワーク外周面を、ワーク自転時にワークのセンター軸より最も遠距離となるワーク外周軌跡の外周面巾に沿って近似した形状の軸心円周方向部片(9)(9')とそれに連なる円周方向コイル部片(8)(8')とからなるループ状高周波誘導コイル体(7)により加熱した後、冷却して該ワークの外周面巾にわたって同時にほぼ均一な表面硬化層を得るようにした高周波表面焼入方法。

(2) 軸心を異にする異形屈曲物のワーク(1)自転時に、このワークのセンター軸(2)より最も遠距離となるワークの外周軌跡の外周面巾に沿って近似した形状で、センター軸(2)の軸線に対しほぼ上下対称な軸心方向コイル部片(9)(9')と、このワーク(1)両端の外周面に沿ったほぼ半円形状で上記軸心方向コイル部片(9)(9')の両端にそれぞれ連なる両円周方向コイル部片(8)(8')とからなり該ワークの外周面巾にわたって同時にほぼ均一な表面硬化層を得るようにした高周波表面焼入方法に用いるループ状高周波誘導コイル体。

3. 発明の詳細な説明

本発明は軸心を異にする異形屈曲物のワークの外周面をループ状高周波誘導コイルにより加熱した後冷却する高周波表面焼入方法並びにそれに用いるループ状高周波誘導コイル体に関する。一般に軸心を異にするクランクシャフトのような異形屈曲物のワークを焼入する方法としては浸炭焼入法が用いられているが、この浸炭焼入法では浸炭鋼を用いることおよび、焼入されたワークは外表面に連続した表面硬化層が得られること等のために疲労強度に対し優れた性能を有する反面、高価な浸炭鋼の使用によって経済的な観点より明らかに不利であった。そこでこの浸炭鋼に比較し安価なS40C(JIS規格)等の炭素鋼又は低合金

鋼等の鋼材による高周波表面焼入方法を採用するに至ったのであるが、上記の如くワークの形状が極めて複雑で回転中心であるセンター軸からの距離差又は肉厚の差が大きいために、従来の割型タイプ又は、ループ状型の高周波誘導コイルでこのワーク全外周面を同時にほぼ均一に表面焼入することは不可能とされていた。即ち、ワーク全外周にほぼ近似した形で囲繞する割型コイルによる均一加熱は不可能であり、この複雑なワークの自転時のセンター軸より最も遠距離となるワーク外周軌跡に近似した形状のループ状の高周波誘導コイルではコイルに最も近接したワーク部分と遠隔の部分との温度差が大きく表面焼入は不可能と考えられていた。

本発明は上記の点に鑑みて、従来不可能とされていた異形屈曲物のワークを浸炭鋼に比較し安価な鋼材例えば炭素鋼又は低合金鋼等にて製作した高周波誘導コイルによって加熱後冷却してこのワークにほぼ均一な表面硬化層を得ることのできる極めて画期的な高周波表面焼入方法並びにそれに

用いるループ状高周波誘導コイル体を提供するにある。

以下本発明を図面に基き説明する。

第１図は本発明の１実施例を示す概略図、第２図は本発明によって生起する電流の経路を示す説明図、第３図は本発明ループ状高周波誘導コイル体をワークに配備した状態を示す平面図である。

本発明方法を第１図の実施例によって説明すると第１図に於いては、回転軸(3)により回転される支持棒(4)を１回転する間にこの支持棒(4)に挟持された異形屈曲物のワーク(1)を自転させながら加熱冷却する型式（以下この型式を回転型式と称す）であって、高周波発生器(10)からの電流はワーク自転時にワークセンター軸より遠距離となるワーク外周軌跡の外周面巾に沿った形状の本発明ループ状高周波誘導コイル体(7)によりワーク(1)外周面全体を同時に表面加熱後支持棒(4)が１２０度回転してワーク(1)を挟持した状態で冷却液(16)中に浸漬される、この冷却に際してはこの冷却液中に冷却液噴射ジャケット（図示せず）を配備して同時に冷

却してもよく又噴射ジャケットのみにて冷却してもよい、このような回転型式にすれば自動的に加熱冷却ができて作業能率の向上を測ることができるが勿論本発明はこの回転型式に限定されるものでなく、加熱、冷却を行う型式であれば何ら支障はない。

又、この回転型式によれば高周波誘導コイル体(7)は上記ワーク(1)自転時のワーク外周軌跡の外周曲率に沿ってほぼ１８０度の角度範囲に置かれるのが最適である。このことはワーク外周面を均一に加熱しながらしかも加熱時間を短くすることができるので支持棒(4)を１回転する間に加熱冷却を行う回転型式では冷却に対し無駄な冷却時間を必要とすることがないためにタクトタイムが短かくなり、加工能率が上昇する。

本発明は上記に述べたように回転型式に限定されるものではないのでこの高周波誘導コイル体(7)の角度範囲も１８０度に限定されるものでない。

上記自転しているワーク(1)を囲繞した本発明ループ状高周波誘導コイル体(7)に高周波発生器(10)の

高周波電流を通電すると第２図に示すように高周波電流は入力端子からループ状高周波誘導コイル体に通電され、ある瞬間矢印(A)の方向に流れ出力端子に向うそれと同時に自転しているワーク(1)の外周面に近い内部には高周波電流と全く逆の矢印(B)方向の誘導電流が生起ししかもこの誘導電流はワーク外周面内に沿って均一に流れるためワーク外周面をほぼ均一に加熱することとなる。

勿論、本発明によればワークの一部を高周波焼入することができることは言うまでもない。

次に本発明方法に用いるループ状高周波誘導コイル体について第３図に基き詳述する(1)はセンター軸(2)を軸とする軸部(3)，このセンター軸(2)に対し偏心軸を有する偏心部(4)，並びにこの軸部(3)と偏心部(4)間の傾斜部(5)とが一体的に形成されたコンプレッサー用のクランクシャフトのような異形屈曲物のワークで、このワーク(1)の先端はチャック(8)等により挟持されており、このワーク(1)は更にチャック(8)後部に位置する駆動装置（図示せず）によってこのワークのセンター軸(2)を中心として

自転している。(7)はこのワーク(1)外周面を同時にほぼ均一に加熱するループ状高周波誘導コイル体で、一対の円周方向コイル部片(8)(8')と、軸心方向コイル部片(9)(9')とからなり、この円周方向コイル部片(8)(8')と軸心方向コイル部片(9)(9')とを交互に連結して該ワークを囲繞するように形成されている。この高周波誘導コイル体(7)の横断面形状は丸形又は方形とし中空部に冷却液を通ずるようにしてある。円周方向コイル部片(8)(8')は上記ワーク両端で所定間隙隔ててほぼ半円形状に形成されており、一方の円周方向コイル部片(8)には高周波発生器(10)の電流を通電する[illegible]端子が配設されている。(11)は[illegible]端子を配設した円周方向コイル部片(8)の中央に設置されたテフロン等の絶縁材である。軸心方向コイル部片(9)(9')は上記ワーク(1)がセンター軸(2)を中心として自転した時、センター軸(2)より最も遠距離となるワーク外周面軌跡の外周面巾に近似した形状に形成され、かつ上記円周方向コイル部片と同様に所定間隙隔ててセンター軸の軸線に対しほぼ上下対称に配備されている。又、このコイル部

(7)

片(8，8'，9，9')の一部の最外周に加熱を強化したり、均熱化を図るためコアを付設することもある。

以上の如く本発明は異形屈曲物のワークを自転させながら、この自転時にワークのセンター軸より遠距離となるワーク外周軌跡の外周面巾に沿った形状のループ状高周波誘導コイル体によって表面加熱後冷却しているので、従来の浸炭鋼に比較して安価な[illegible]炭素鋼[illegible]にて異形屈曲物のワークが表面[illegible]焼入できる画期的な焼入方法であり、しかもワークに連続した表面硬化層を得ることができ、ワークの疲労強度を飛躍的に増大させることができる。

4. 図面の簡単な説明

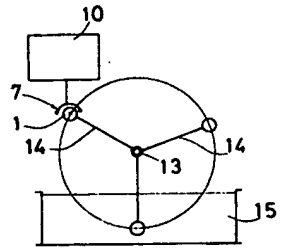
第1図は本発明方法の一実施例を示す概略図、第2図は本発明によって生起する電流の経路を示す説明図、第3図は本発明ループ状高周波誘導コイル体をワークに配備した状態を示す平面図である。

1…ワーク，2…センター軸，3…軸部，4…偏心部，5…傾斜部，6…チャック，7…高周波誘導コイル体，8,8'…円心方向コイル部片，9，9'…軸心方向コイル部片，10…高周波発生器，11…絶縁材，13…回転軸，14…支持棒，15…冷却液，A…高周波電流，B…誘導電流。

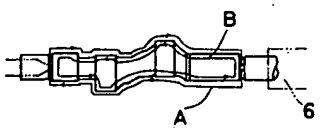
－以上－

(8)

第1図

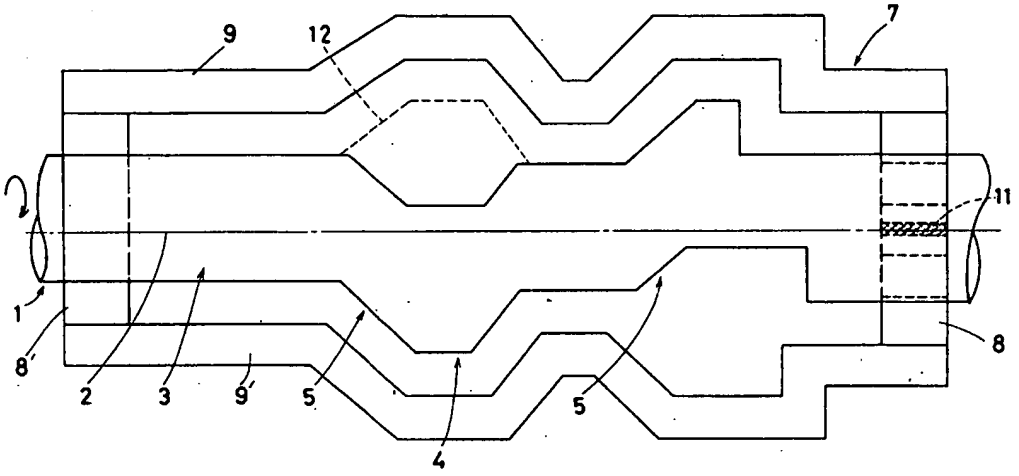


第2図



(9)

第 3 図



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Japanese Published Unexamined (Kokai) Patent Publication No. 55-065320; Publication Date: May 16, 1980; Application No. 53-139182; Application Date: November 10, 1978; Int. Cl.[3]: C21D 1/62 1/10 1/42 H05B 6/36; Inventor: Masayuki Kayahara; Applicant: Fuji Denshi Kogyo K.K.; Japanese Title: Koushuuha Hyoumen Yakiire Houhou narabini soreni Mochiiru Ruupujou Koushuuha Dendou Koirutai (High Frequency Surface Quenching Method and Loop-Shaped High Frequency Induction Coil Used Therefor)

Specification

1. Title of Invention

High Frequency Surface Quenching Method and Loop-Shaped High Frequency Induction Coil

2. Claim(s)

1. A high frequency surface quenching method, characterized in that while a work 1 that is a variously bent article having various axial cores is self-rotated, the outer circumferential surface of the work is heated with a loop-shaped high frequency induction coil 7 being comprised of axial core circumferential direction pieces 9 and 9' that approximate along the width of the surface on an outer circumferential orbit of the work to be most far from the central axis of the work during the self rotation of the work and circumferential direction coil pieces 8 and 8' connected to the circumferential direction pieces 9 and 9'; after the heating, the outer circumferential surface of the work is cooled so as to obtain an almost uniform hardened surface layer throughout the width of the outer circumferential surface of the work at once.

2. A loop-shaped high frequency induction coil used for a high frequency surface quenching method, characterized being comprised of axial core direction coil pieces 9 and 9' almost vertically symmetrical to the axial line of a central axis 2 and semi-circular circumferential direction coil pieces 8 and 8' that are connected to both ends of the axial direction coil pieces 9 and 9' along the outer circumferential surface of both ends of a work 1, while being approximated along the width of the surface on an outer circumferential orbit of the work to most far from the central axis 2of the work during a self rotation of the work 1 that is a variously bent article having various axial cores; in that a hardened surface layer almost uniform throughout the width of the outer circumferential surface of the work is obtained at once.

3. Detailed Description of the Invention

This invention pertains to a high frequency surface quenching method for cooling the outer circumferential surface of a variously bent work having various axial cores after it has been heated using a loop-shaped high frequency induction coil and to the loop-shaped high frequency induction coil used therefor. A carburization quenching method is generally used as a method for quenching a variously bent work having various axial cores, such as a crankshaft. At the carburization quenching method, the work demonstrates high performance to fatigue strength as carburization steel is used and as a hardened surface layer continued to the outer surface is obtained in the quenched work. On the other hand, the carburization method is obviously disadvantageous in terms of a cost saving because of the use of carburization steel. Accordingly, a high frequency surface quenching method using a steel material at a cost lower than that of carburization

steel, such as carbon steel or low alloy steel, is finally used. Since the shape of the work is extremely complicated as described above and since the difference in the distance or thickness from the central axis as the rotating center is large, it is not possible to almost uniformly quench the whole outer circumferential surface of the work at once using a conventional split type or loop-shaped high frequency induction coil. More specifically, a uniform heating using a split type coil wound around the whole outer circumference of the work while it is almost approximated thereto is not possible. At a loop-shaped high frequency induction coil approximated to the orbit of the outer circumference of the work to be most far from the central axis at a complicated self rotation of the work, the difference in the temperatures of the work part most approximated to the coil and the most remote part is large. For this reason, a quenching of the surface is assumed to be impossible.

In consideration of the disadvantages as described above, the present invention is produced to offer an extremely innovative high frequency surface quenching method that can obtain an almost uniform hardened surface layer on a variously bent work, in which the surface quenching is previously not possible, by cooling it after it has been heated using a high frequency induction coil made from a steel material at a cost lower than that of carburization steel, such as carbon steel or low alloy steel, and offer a loop-shaped high frequency induction coil used therefor.

The invention is described hereinbelow with reference to the drawings.

Fig.1 is a schematic diagram illustrating a working example of the invention. Fig.2 illustrates a route of current generated by the invention. Fig.3 is a top view

illustrating a loop-shaped high frequency induction coil of the invention, being provided on a work.

The method of the invention is described with reference to the working example of the invention. In Fig.1, while a support rod 14 that revolves using a spindle 13 is revolved once, a variously bent work 1 supported with the support rod 14 is heated and cooled while being self-rotated (henceforth referred to as a rotary type). The current from a high frequency generator 10 heats the entire outer circumferential surface of the work 1 at once using a loop-shaped high frequency induction coil 7 of the invention, which is along the width of the surface on an outer circumferential orbit of the work that is to be most far from the central axis of the work during a self-rotation thereof. After this, the support rod 14 rotates by 120° to immerse the work 1 in a cooling solution 15 while the work is being griped. The cooling can be performed at once by providing a cooling solution ejecting jacket (as not shown in the drawing) in the cooling solution or by using the ejecting jacket alone. With this rotary type, a heating and cooling is automatically applied to improve the work efficiency. The invention is not limited to the rotary type alone and can be any types as long as a heating and cooling is applied.

According to the rotary type, it is optimal that the high frequency induction coil 7 is placed at almost 180° along the curvature of the outer circumferential orbit of the work being self-rotated. Thus, the heating period is reduced while the outer circumferential surface of the work is uniformly heated. At the rotary type that performs the heating and cooling during a single rotation of the support rod 14, an unnecessary cooling period is not required to the cooling, thereby reducing the tact time to improve the processing efficiency.

As described above, as the invention is not limited to the rotary type, the angle of the high frequency induction coil 7 is not limited to 180° as well.

At conduction of high frequency current of the high frequency generator 10 to the loop-shaped high frequency induction coil 7 of the invention, which is wound around the self-rotating work 1, as shown in Fig.2, the high frequency current is conducted from the input terminal to the loop-shaped high frequency induction coil. In a certain moment, the current flows in an arrow A direction and directs to the output terminal. At the same time, induction current in an arrow B direction, which is completely opposite of the high frequency current, is generated inside the self-rotating work 1 close to the outer circumferential surface. Because this induction current flows uniformly along the inside the outer circumferential surface of the work, the outer circumferential surface of the work is almost uniformly heated.

According to the invention, a part of the work can be quenched using a high frequency.

The loop-shaped high frequency induction coil used for the method of the invention is described next based on Fig.3. Reference number 1 refers to the variously bent work like a crankshaft for a compressor, wherein an axial unit 3 having a central axis 2, an eccentric unit 4 having an eccentric axis to the central axis 2, and an inclination unit 6 between the axial unit 3 and the eccentric unit 4 are integrally formed. The tip of the work 1 is gripped with a chuck 6. The work 1 also self-rotates putting the central axis 2 of the work as a center using a driver (as not shown in the drawing) located at the rear of the chuck 6. Reference number 7 is the loop-shaped high frequency induction coil that almost uniformly heats the outer circumferential surface of the work 1 at once, which is

comprised of a pair of circumferential direction coil pieces 8 and 8' and a pair of axial direction coil pieces 9 and 9'. The two types of coil pieces are alternately connected to wind around the work. The vertical cross-section of the high frequency induction coil 7 is in a circular or rectangular shape and formed so that a cooling solution flows in a hollow part. The circumferential direction coil pieces 8 and 8' are formed in an almost semi-circular shape on both ends of the work. A terminal for conducting current of the high frequency generator 10 is provided on one circumferential direction coil piece 8. Reference number 11 refers to an insulating Teflon material that is provided on the center of the circumferential direction coil piece 8 containing the terminal. The axial core direction coil pieces 9 and 9' are formed into a shape close to the width of the surface on the outer circumferential orbit of the work to be most far from the central axis 2 when the work 1 self-rotates putting the central axis 2 as a center and arranged almost vertically symmetrical to the axial line of the central axis, having predetermined intervals as similarly to as in the circumferential direction coil pieces. A core for reinforcing or uniformizing the heating can be sometimes added to a part of the outer most circumferences of the coil pieces 8, 8', 9 and 9'.

As described above, according to the invention, while the variously bent work is self-rotated, the surface of the work is heated and then cooled using the loop-shaped high frequency induction coil that is in the form along the width of the surface on the outer circumferential orbit of the work to be most far from the central axis during the self-rotation. Thereby, the surface of the variously bent work is quenched using steel materials at a lower cost than that of cement steel, such as carbon steel or low alloy steel, which is

an innovative quenching method. A surface curing layer continued to the work can also be obtained. Therefore, the fatigue strength of the work is rapidly increased.

4. Brief Description of the Drawings

Fig.1 is a schematic diagram illustrating a working example of the method of the invention. Fig.2 illustrates a route of current generated by the invention. Fig.3 is a top view illustrating a loop-shaped high frequency induction coil of the invention, being provided on a work.

1...Work

2...Central axis

3...Axial part

4...Eccentric part

5...Inclined part

6...Chuck

7...High frequency induction coil

8 and 8'...Circumferential direction coil pieces

9 and 9'...Axial direction coil pieces

10...High frequency generator

11...Insulating material

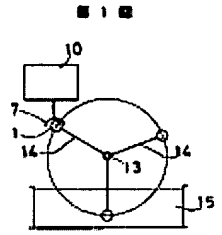
13...Rotating axis

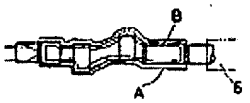
14...Support rod

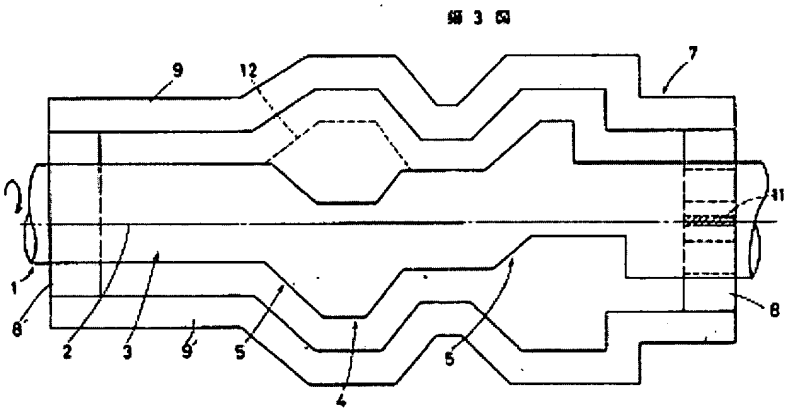
15...Cooling solution

A...High frequency current

B...Inductive current







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